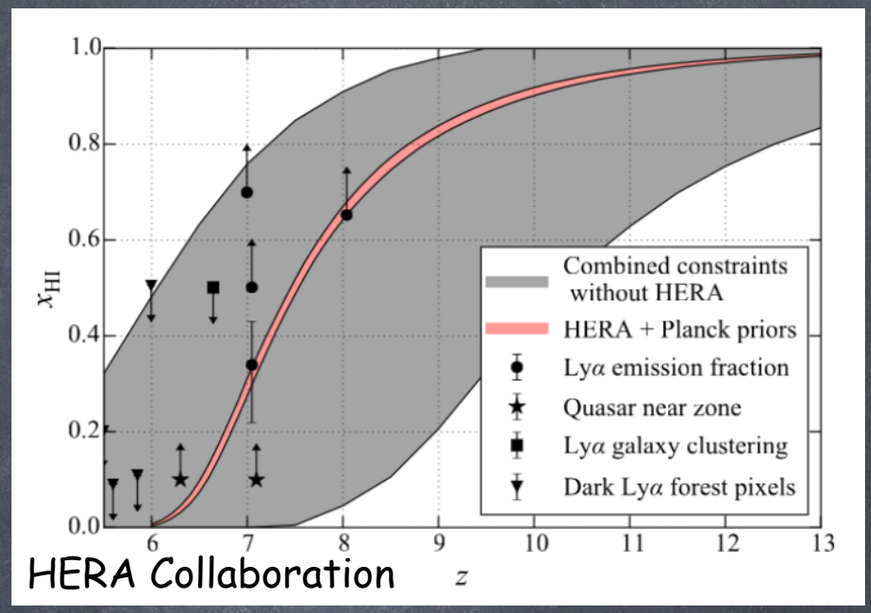
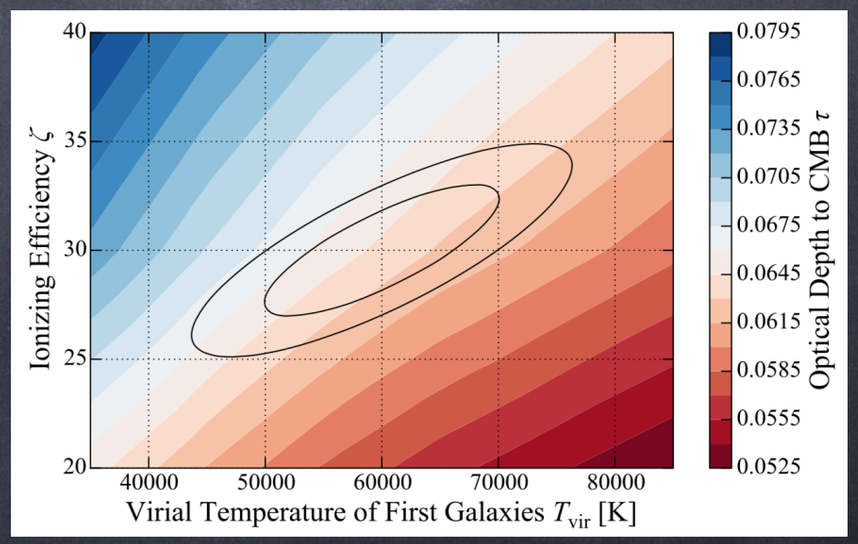
If you think early galaxy formation is a nuisance...

(then you're wrong - BUT:)

- Ongoing efforts to measure reionization through the highly-redshifted 21-cm line are underway (HERA) and in development (SKA-Low)
  - Galaxy-based measurements are subject to major uncertainties
- HERA will make PRECISE constraints of fluctuations in this line, which translate into precise constraints on the optical depth **in the context of a model for reionization**
- Testing those models of reionization requires "imaging" - generation beyond HERA (maybe SKA-Low) OR complementary constraints



HERA Collaboration



Liu et al. (2016)

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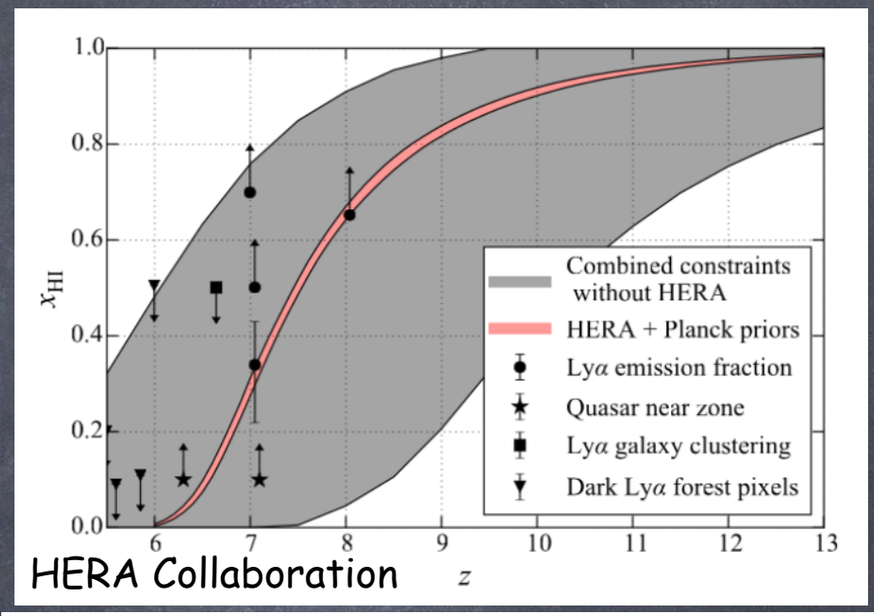

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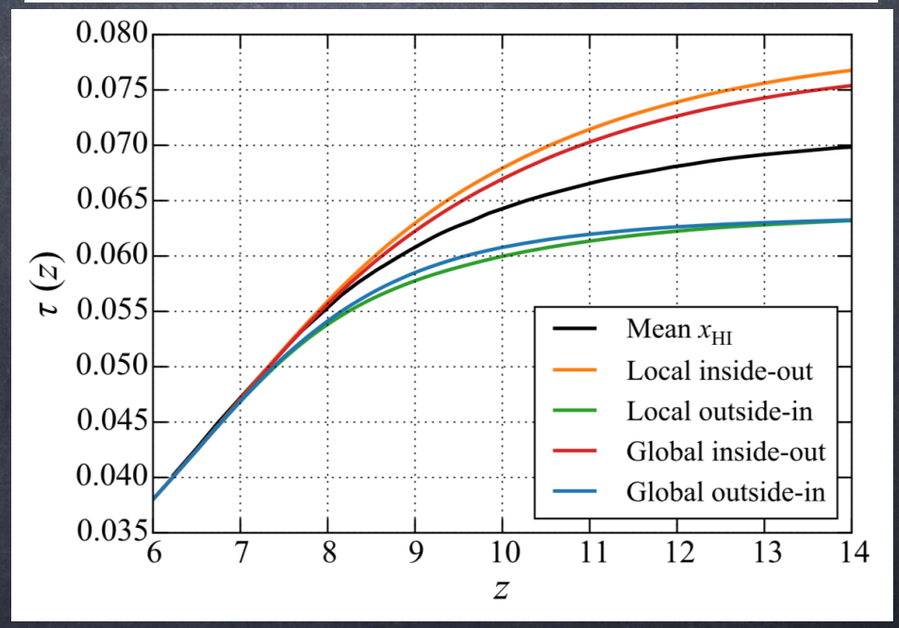

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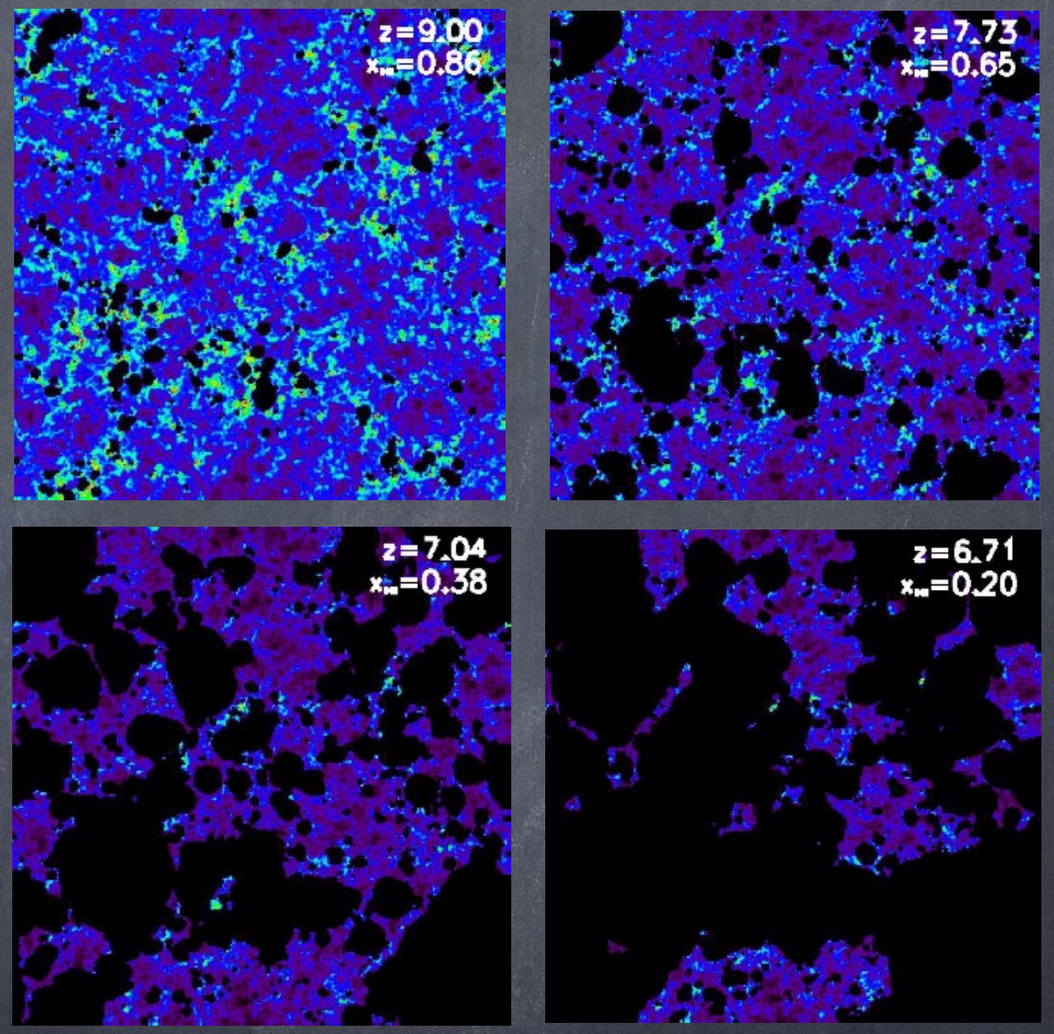
If you think early galaxy formation is actually interesting...

- Conceptually, CMB measurements of reionization suffer from the same problems as 21-cm!
  - Integral over complex reionization field
  - Provides a few independent statistical measurements
    - Extracting physical constraints requires complex modeling…and must retain capability to test these models
- Fundamentally, learning about complex astrophysical processes requires complementary approaches!
- CMB measurements HIGHLY complementary
  - Ionized v. neutral gas
  - IGM v. sources



A. Mesinger

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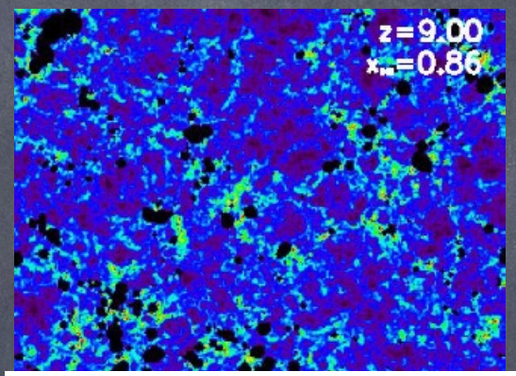
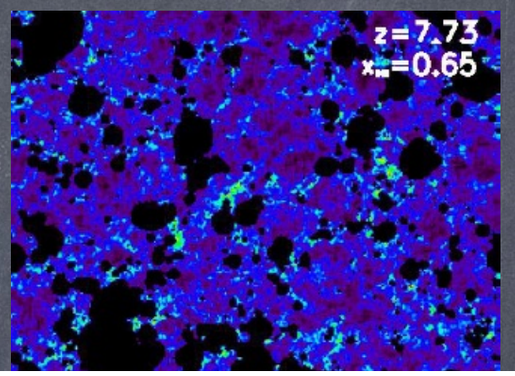
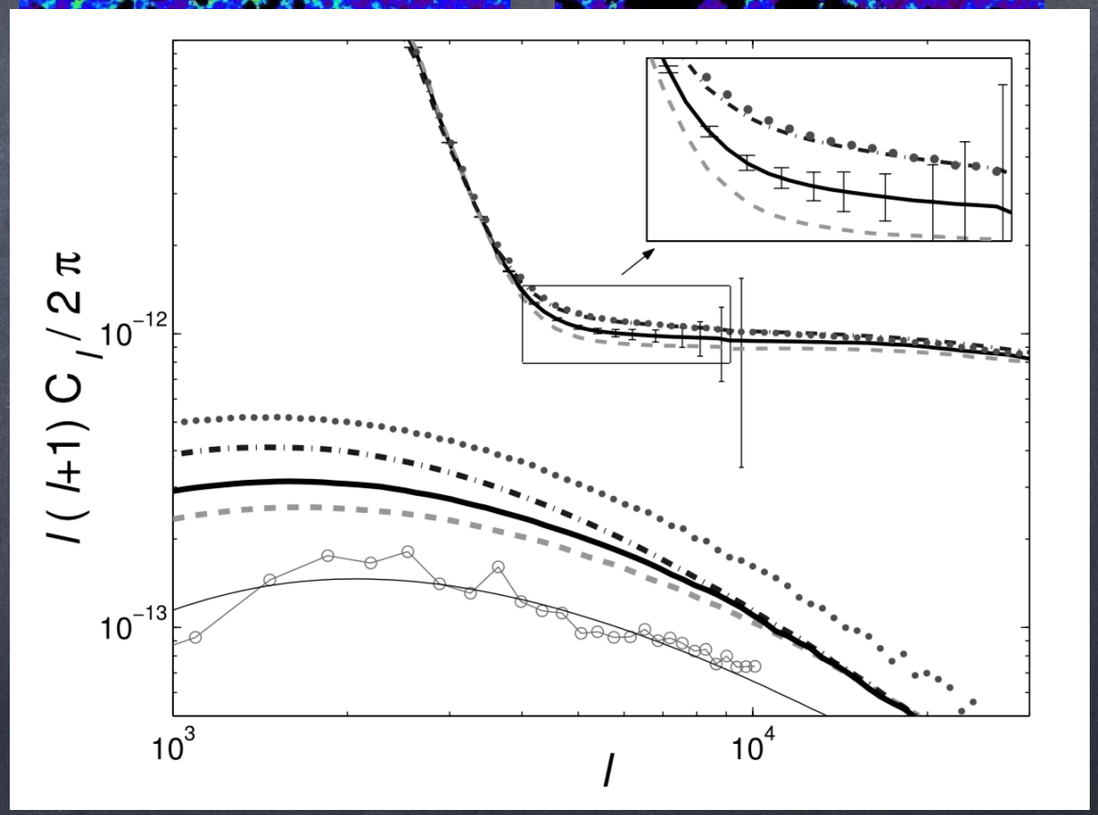


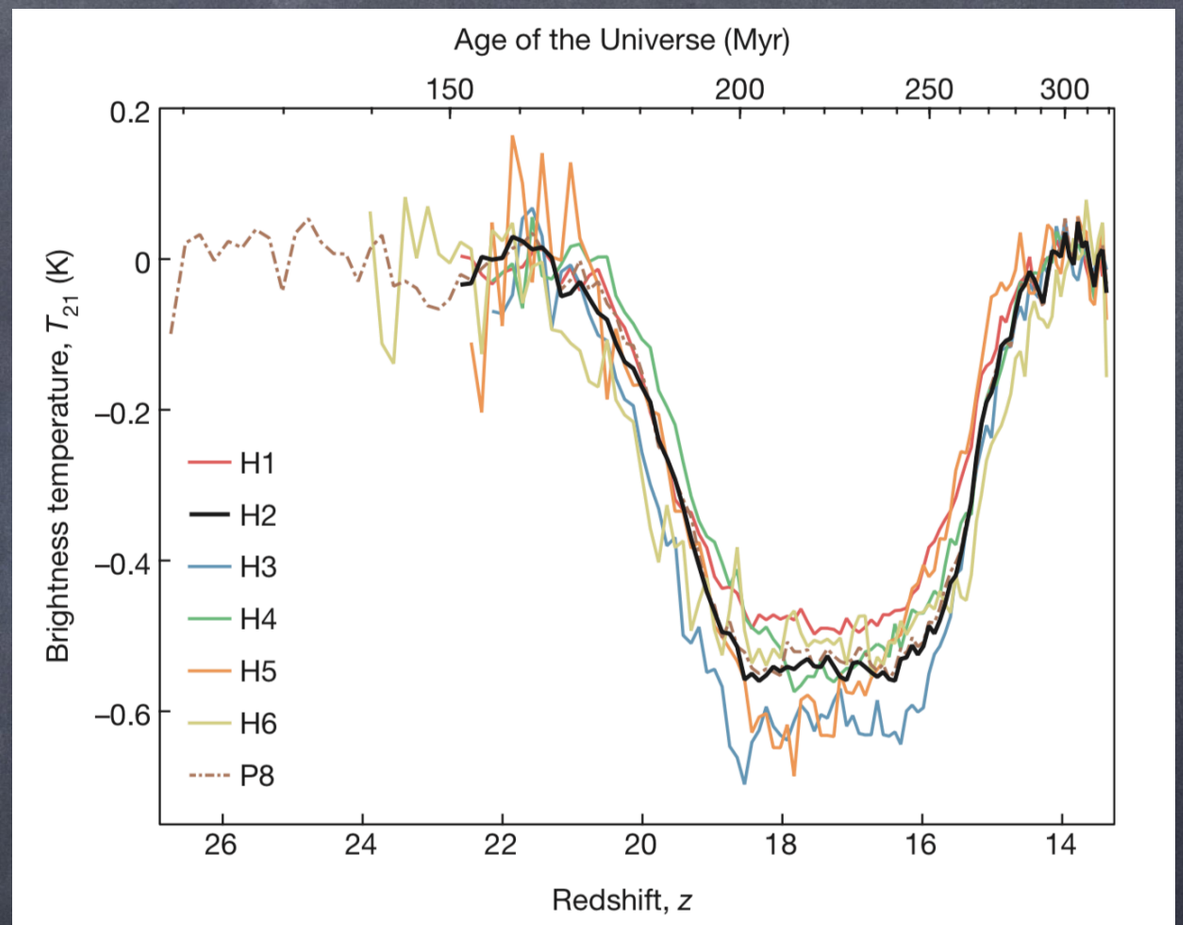




McQuinn et al. (2005)

EDGES

- Weird for three reasons
  - Twice as deep as expected
  - Flat at bottom
  - Earlier than expected from galaxy measurements
- Implications for CMB?
  - ARCADE-2 excess may provide an explanation…but where are the sources from?
  - Lots of early star formation + X-rays?
  - Exotic physics affecting both?



Bowman et al. (2018)